FLOODS IN KARST AREA

CASE STUDY – CROATIA

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KARST

- The karst is a complex concept that specifies specific morphological, hydrological and hydrogeological features of an area.

- It can be found all over the world.

- The thickest known rock complex in the world are Mesozoik carbonate sediments of Dinaric and Adriatic plates in Croatia.

- The karst area is characterized by predominant ground water cirkulation in comparison to surface runoff

- The largest external or surface karst forms are **POLJES** especially represented in the Dinaric Karst system with more than 130 registered poljes.
- The local toponym “polje” (field) has become an international designation for the mentioned concept.

- The poljes are covered by thin layer of Quaternary or Neogene water-impermeable depositions that allow surface runoff

- Every karst polje needs to have one karstic spring and one karst sink at mimimum.
- In reality there are more springs and several dozen or even hundred sinks in one polje.

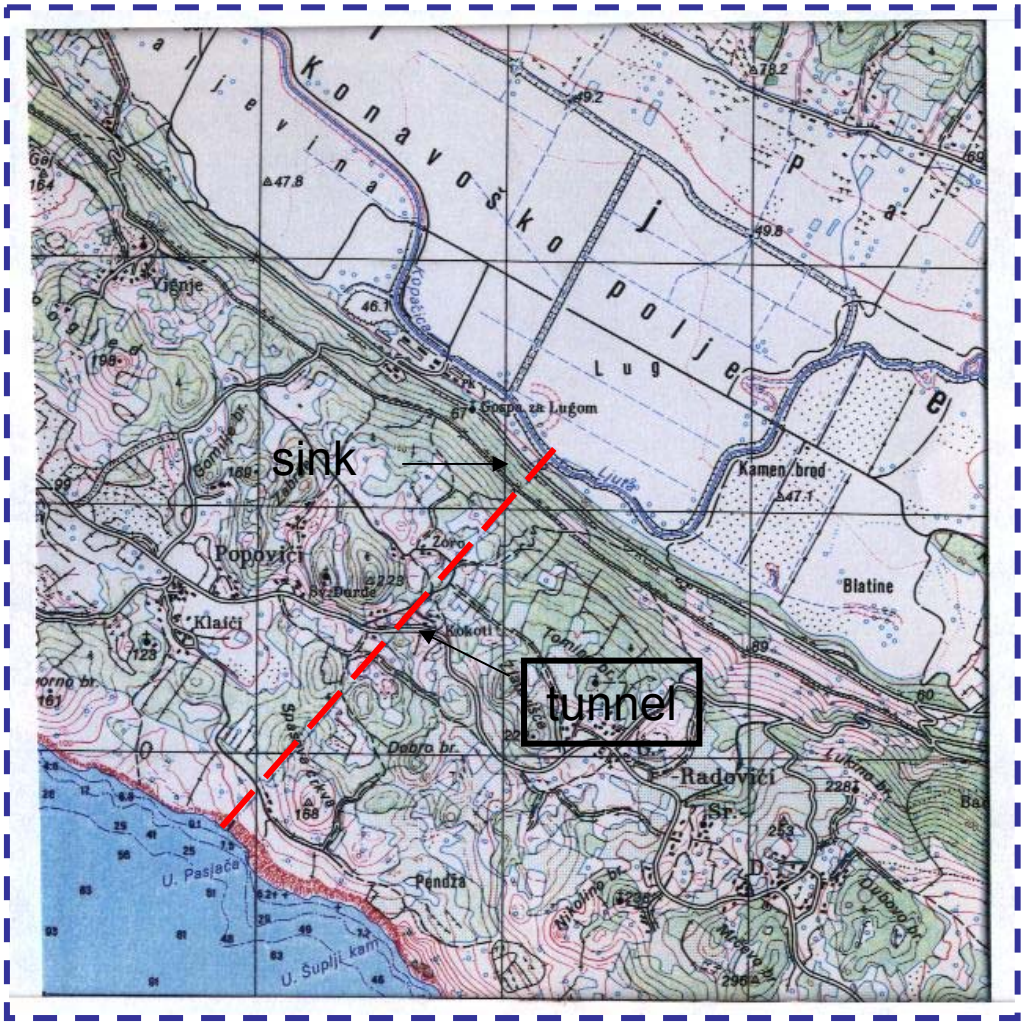
- Poljes are periodicaly flooded because sinks are not able to take surface water quickly enough especially when the underground has already been saturated by water.
- Lower sink capacity is also affected by drifts brought by floods and pulled into sinks.
- In addition to drifts which are also caused by human factor, sinks or their vicinity are recently often used as waste disposals, which has an additional impact on flood increase and frequency.

Flood protection measures

- sink maintenance (cleaning)
- sink protection (e.g. grids)
- tunnel
- detention reservoirs
- reservoirs etc.

Flood protection tunnel

Konavosko polje




Pridvorje
Komaji
Ljuta
Gruda, Konavle, Croati
Popovici
2117 m
Image © 2008 TerraMetrics
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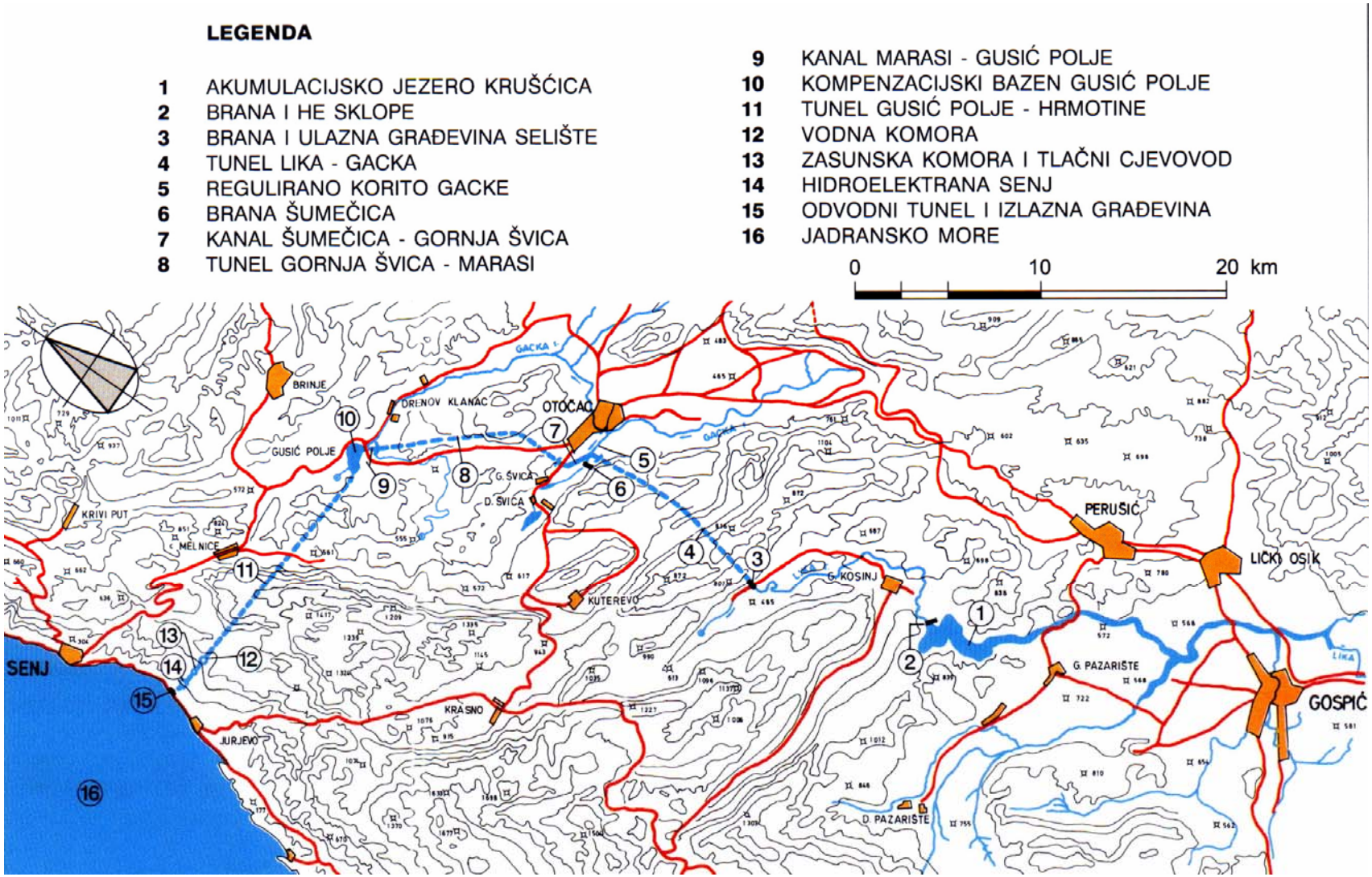
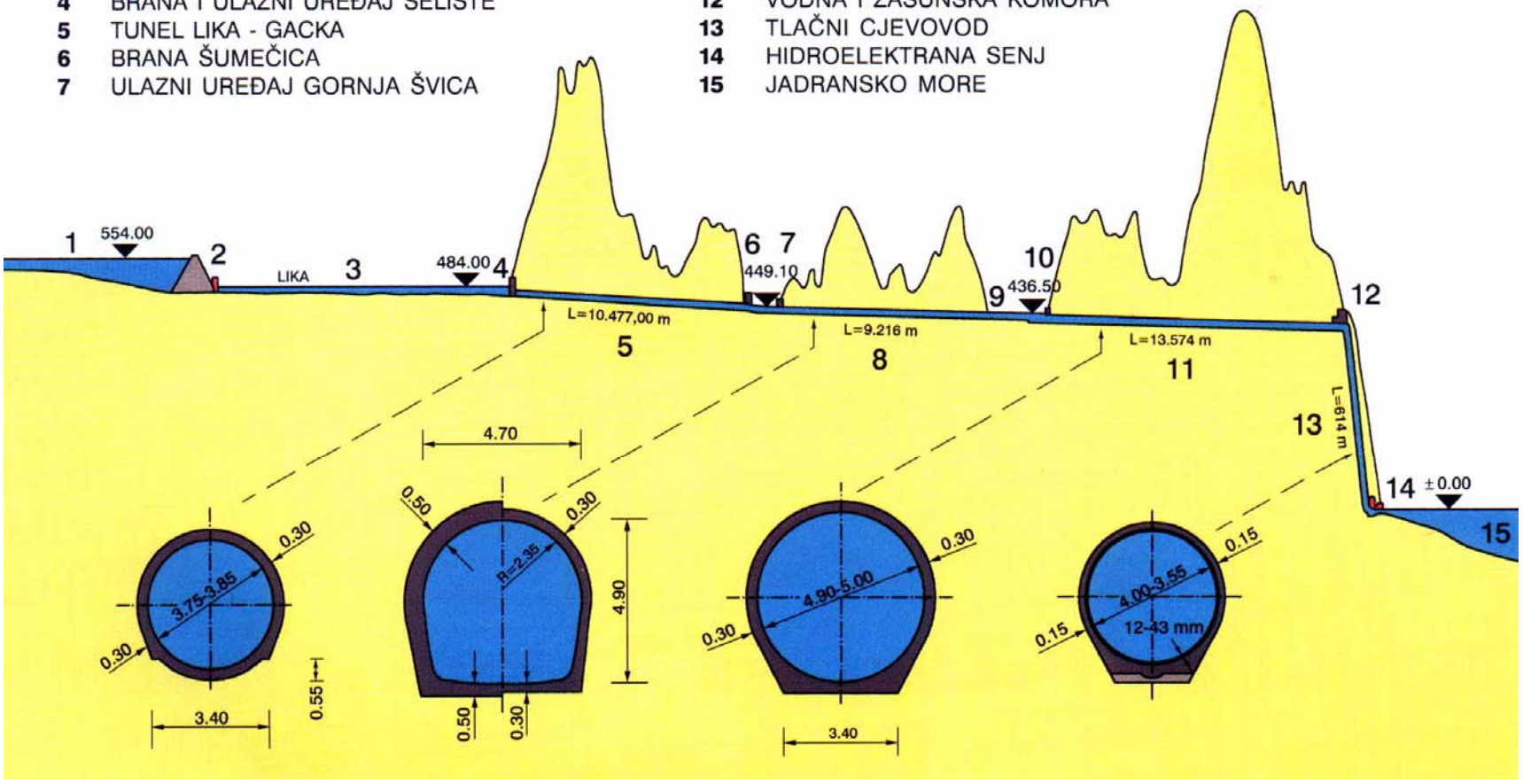
Reservoirs and tunnel
Hydro power plant



LEGENDA

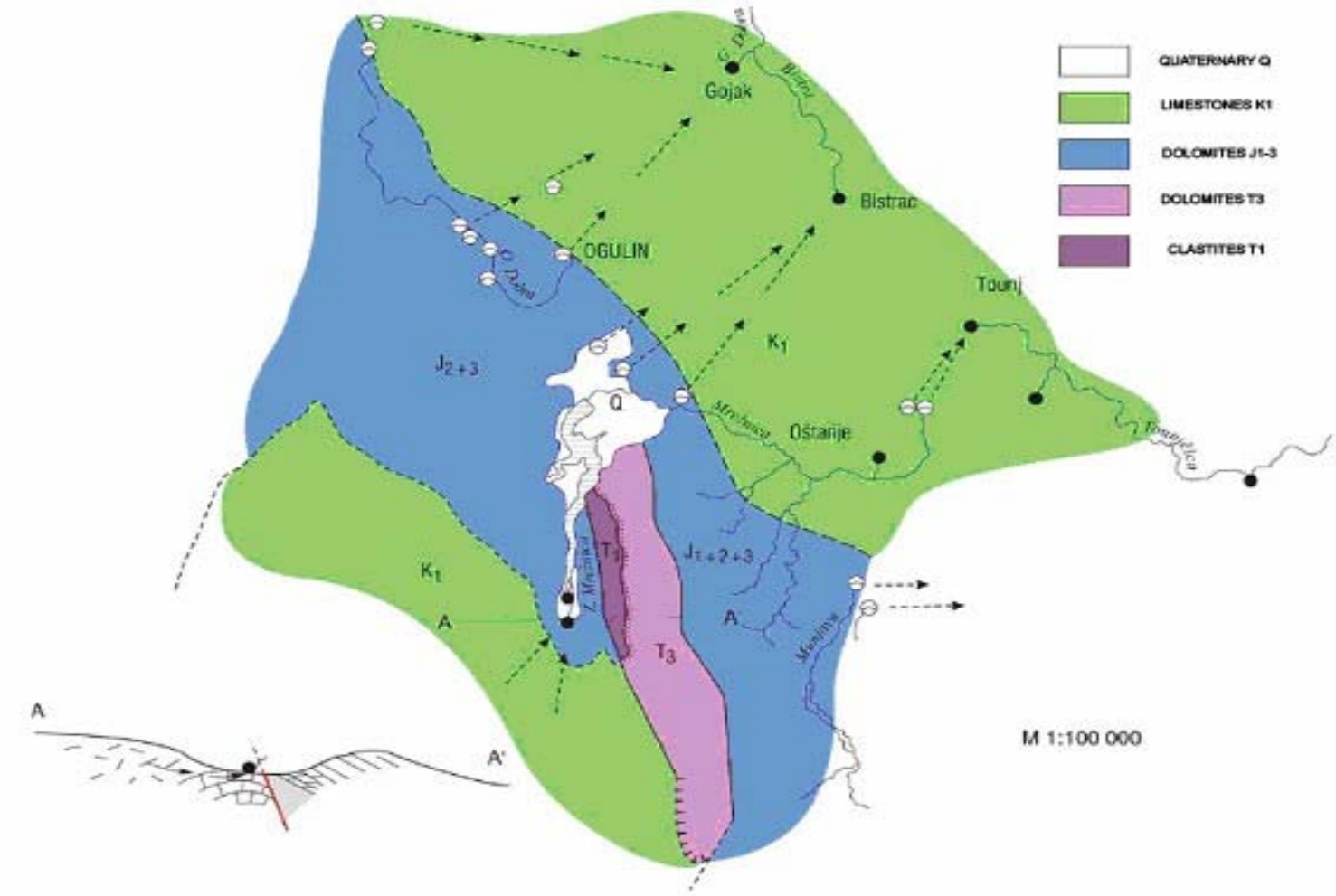
1 AKUMULACIJSKO JEZERO KRUŠĆICA
2 BRANA I HE SKLOPE
3 KORITO LIKE
4 BRANA I ULAZNI UREĐAJ SELIŠTE
5 TUNEL LIKA - GACKA
6 BRANA ŠUMEČICA
7 ULAZNI UREĐAJ GORNJA ŠVICA
8 TUNEL GORNJA ŠVICA - MARASI
9 KOMPENZACIJSKI BAZEN GUSIĆ POLJE
10 ULAZNI UREĐAJ GUSIĆ POLJE
11 TUNEL GUSIĆ POLJE - HRMOTINE
12 VODNA I ZASUNSKA KOMORA
13 TLAČNI CJEVOVOD
14 HIDROELEKTRANA SENJ
15 JADRANSKO MORE



Ogulinsko polje

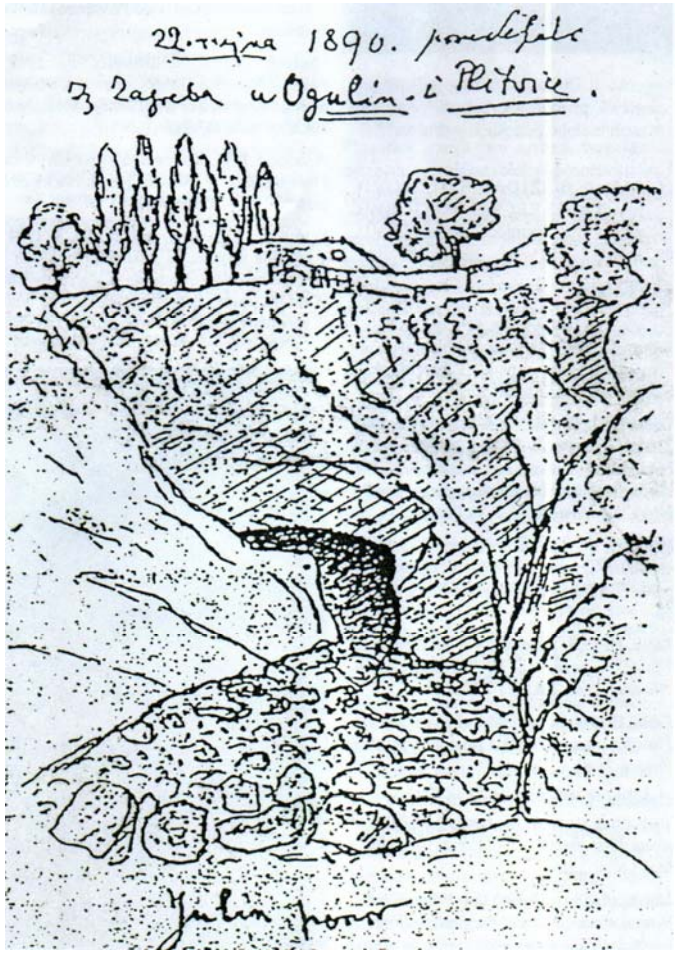
- There are two important rivers in Ogulin polje:
- Zagorska Mrežnica River and Gornja Dobra River

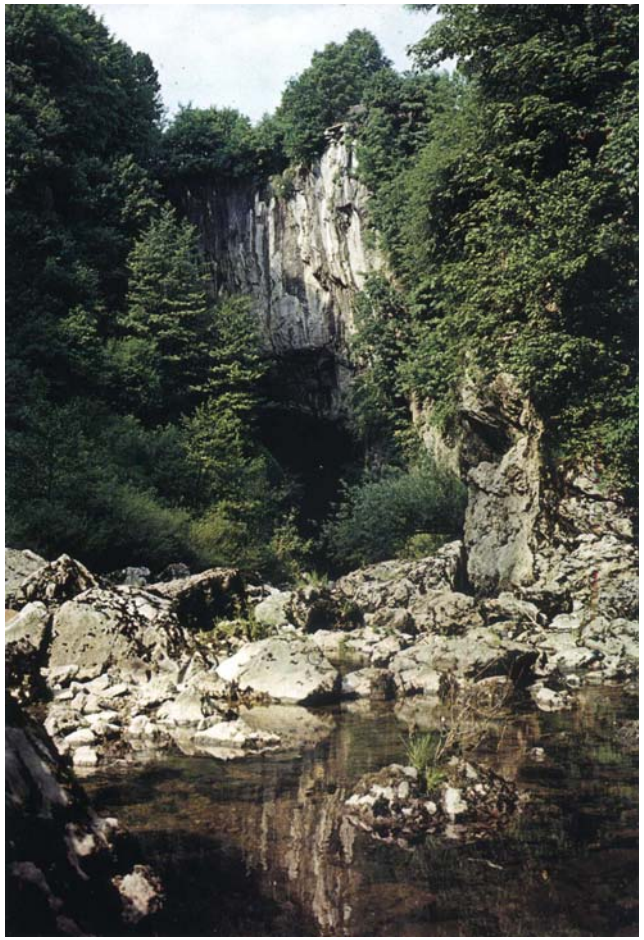
Geological map of the Ogulin region



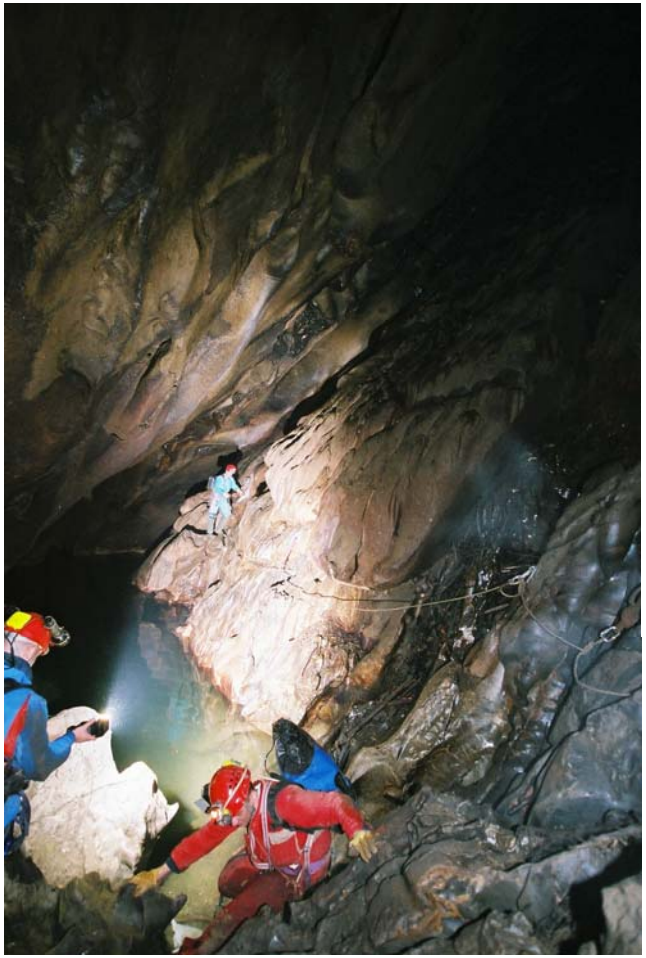
Djula - Medvjednica cave system

- The Ogulinska Dobra River sink is a dominant sink in the town of Ogulin, which constitutes a cave system known as Djula-Medvednica cave system



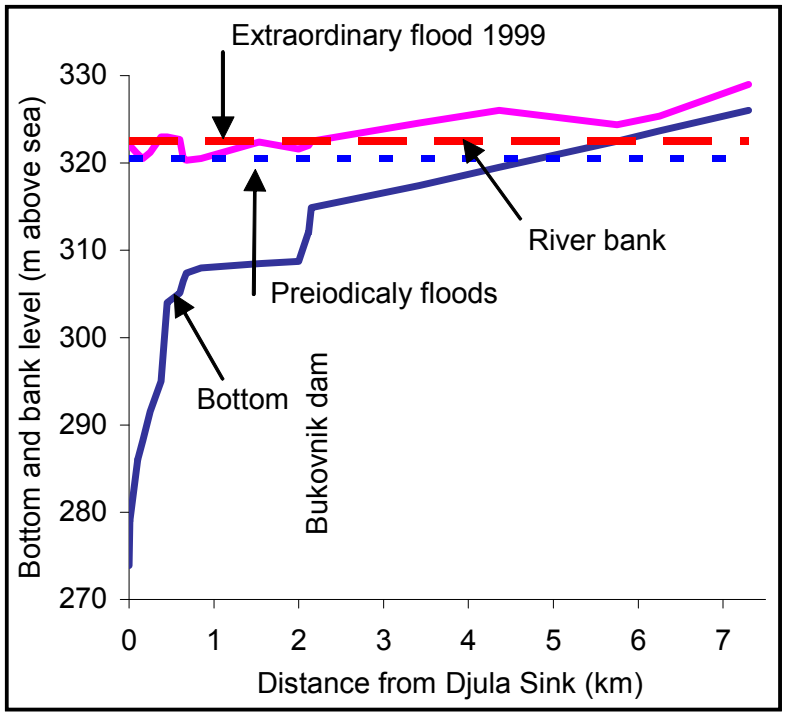


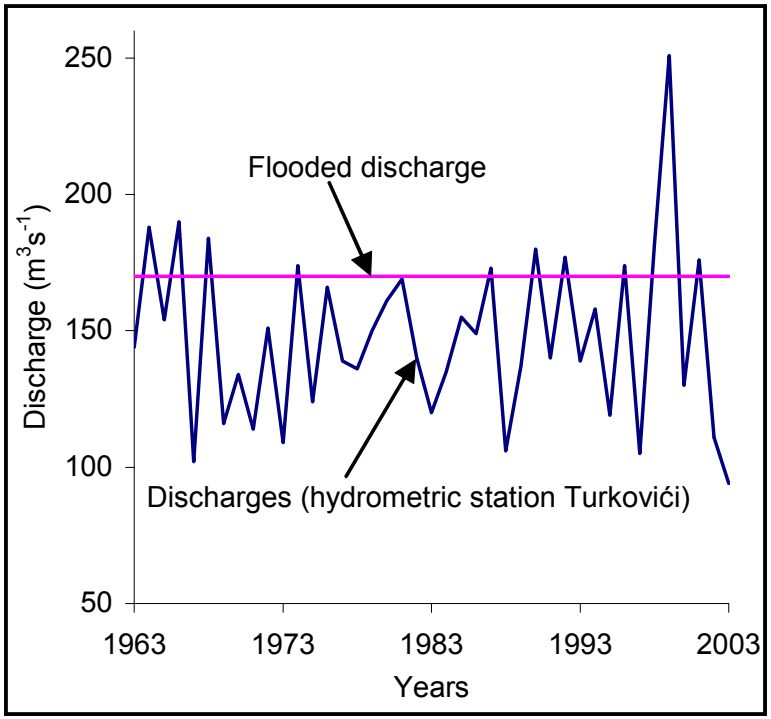
Djula sink inside



Floods in Ogulin

- The sink canyon is more than 45 m, but flooded discharges are not so rare



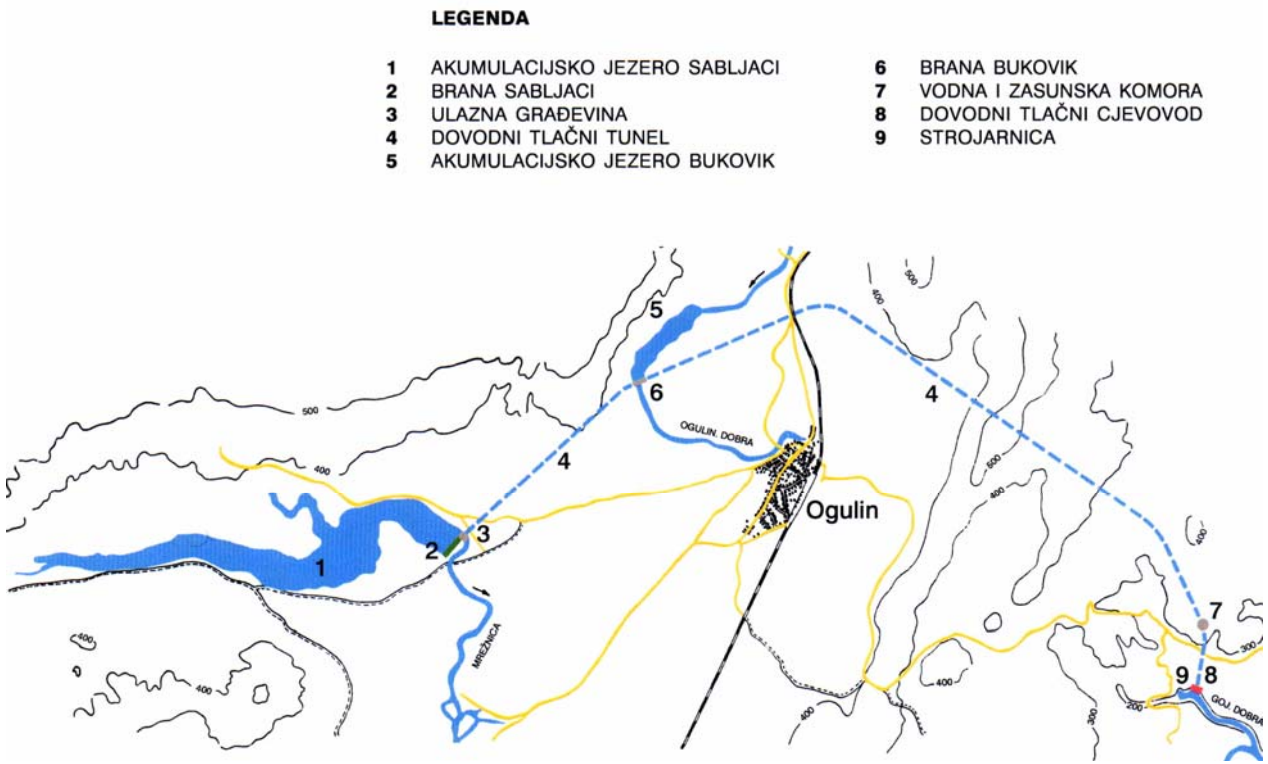


- empty canyon

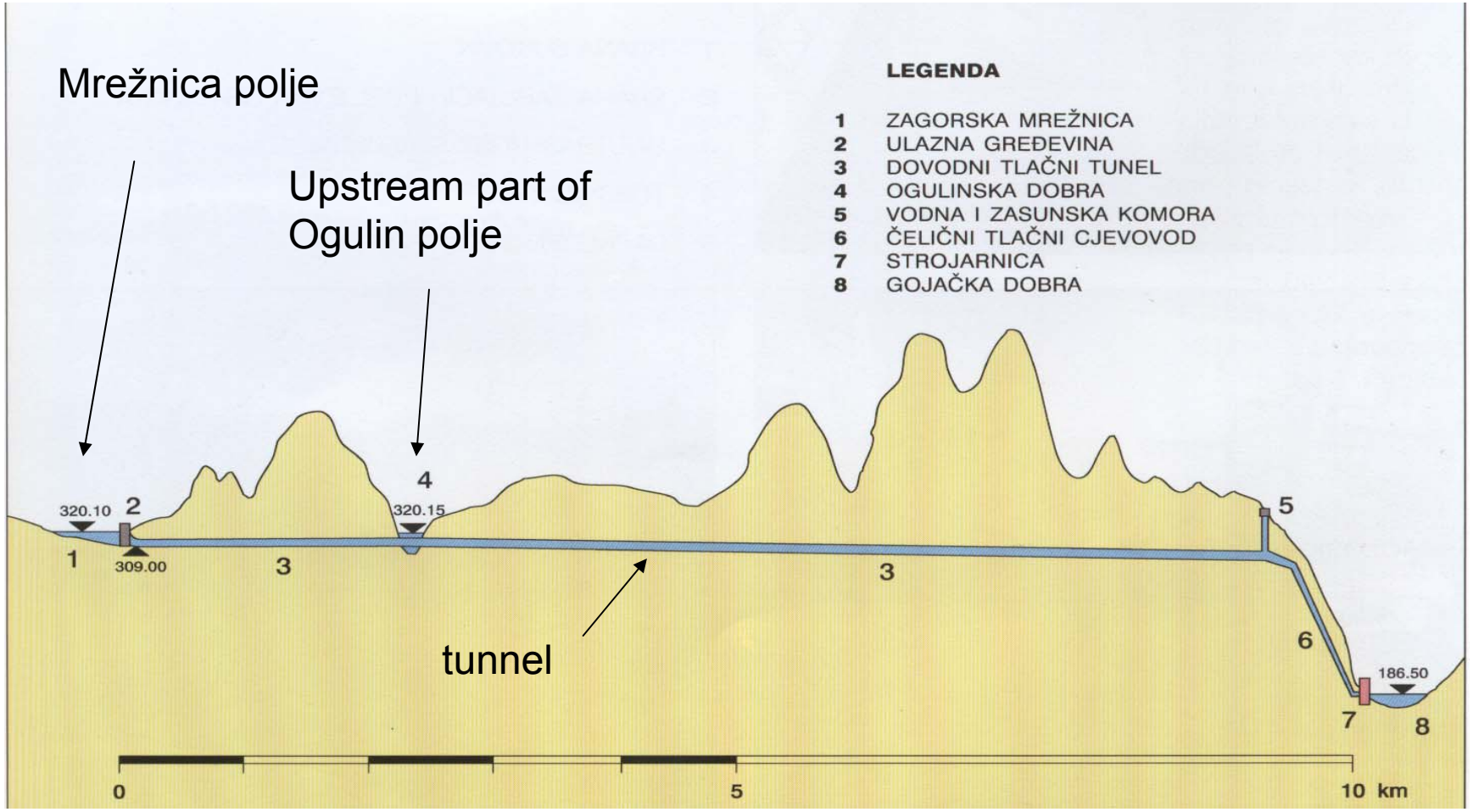
full canyon

Existed flood protection measures

- The sink capacity is dependent on water level in canyon (40 – 90 m^3s^{-1})
- Hydropower plant (constructed in 1959) with installed capacity of 50 m^3s^{-1}



Longitudinal cross section
HEPP Gojak

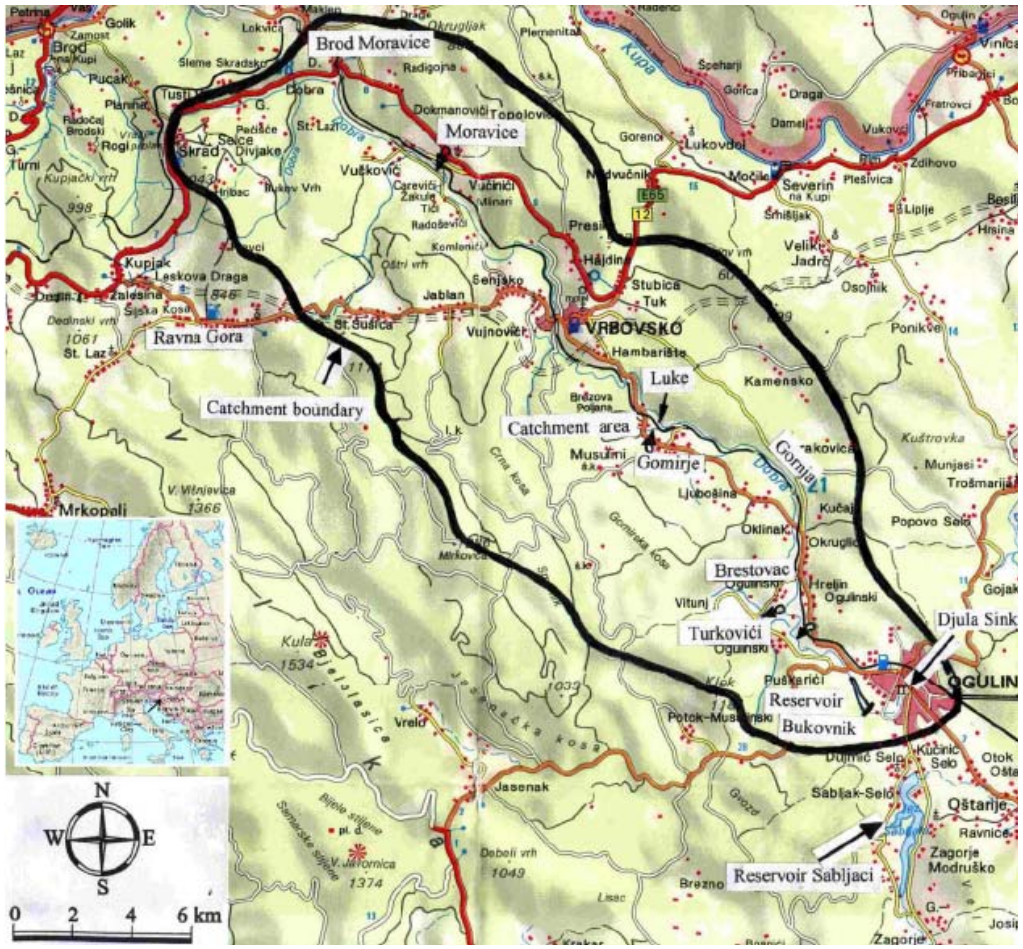


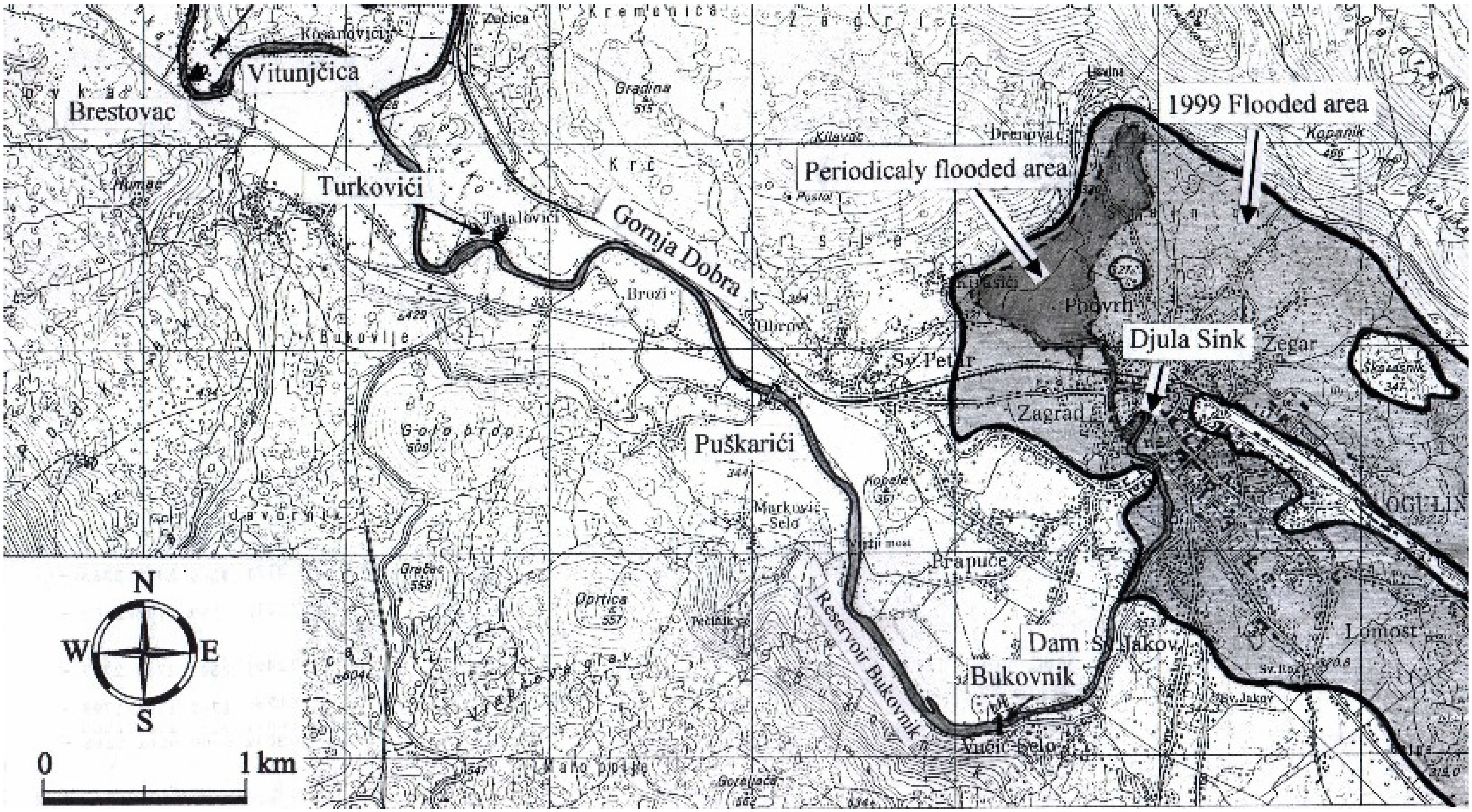
Bukovnik reservoir (240,000 m^3) (Gornja Dobra River)

Sabljaci reservoir (3,300.000 m^3) (Zagorska Mrežnica River)

The extraordinary flood in 1999

- Abundant rains in summer and
- hydropower plant yearly maintenance caused flood with maximum level at 322,5 m above sea (2 m more than usually)





Vitunjčica
Brestovac
Turkovići
Gornja Dobra
Periodicaly flooded area
1999 Flooded area
Djula Sink
Puškarići
Reservoir Bukovnik
Dam
Bukovnik
N
W
E
S
0
1 km


INA

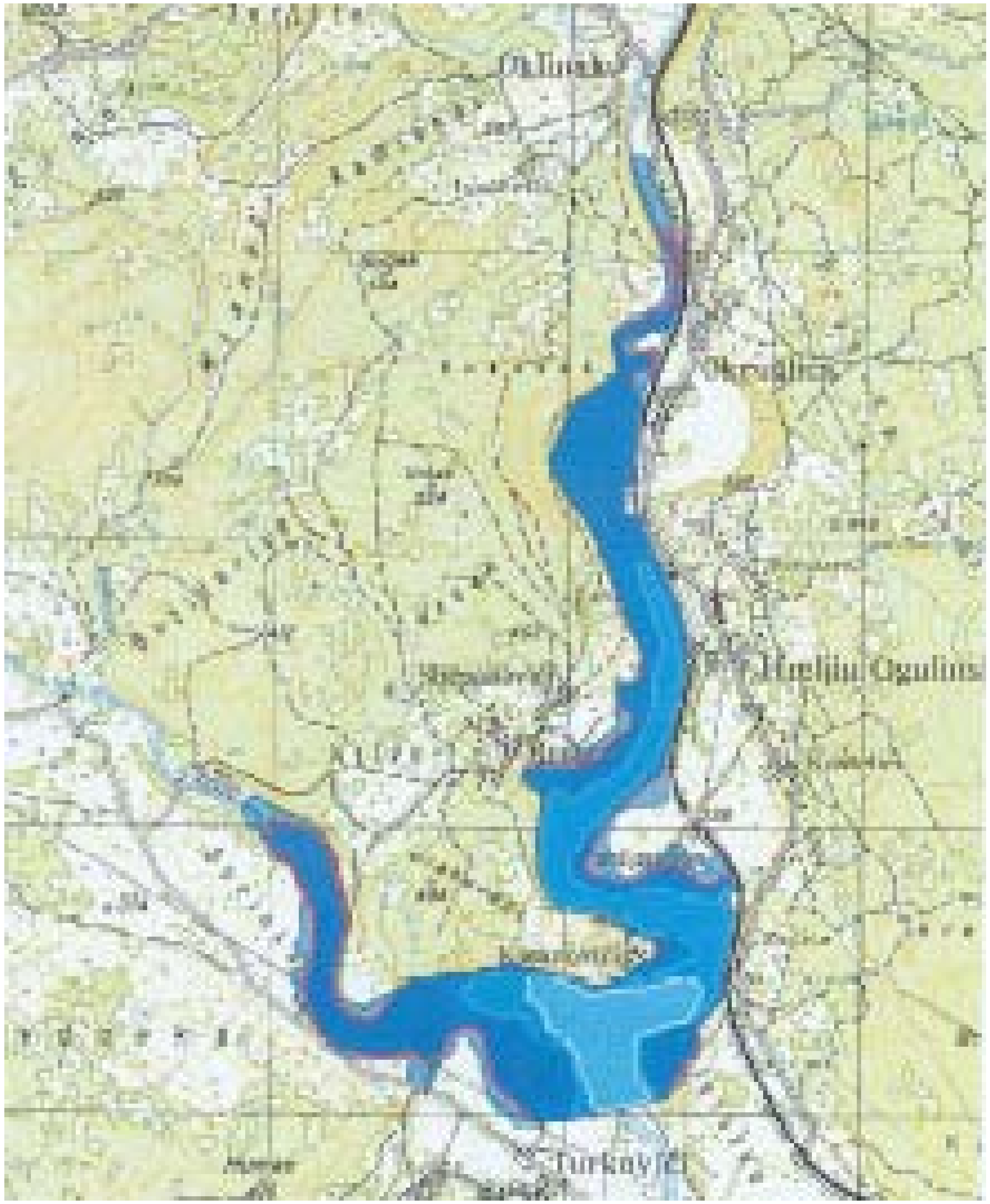
Flood protection measures in Ogulin

Sink capacity increase

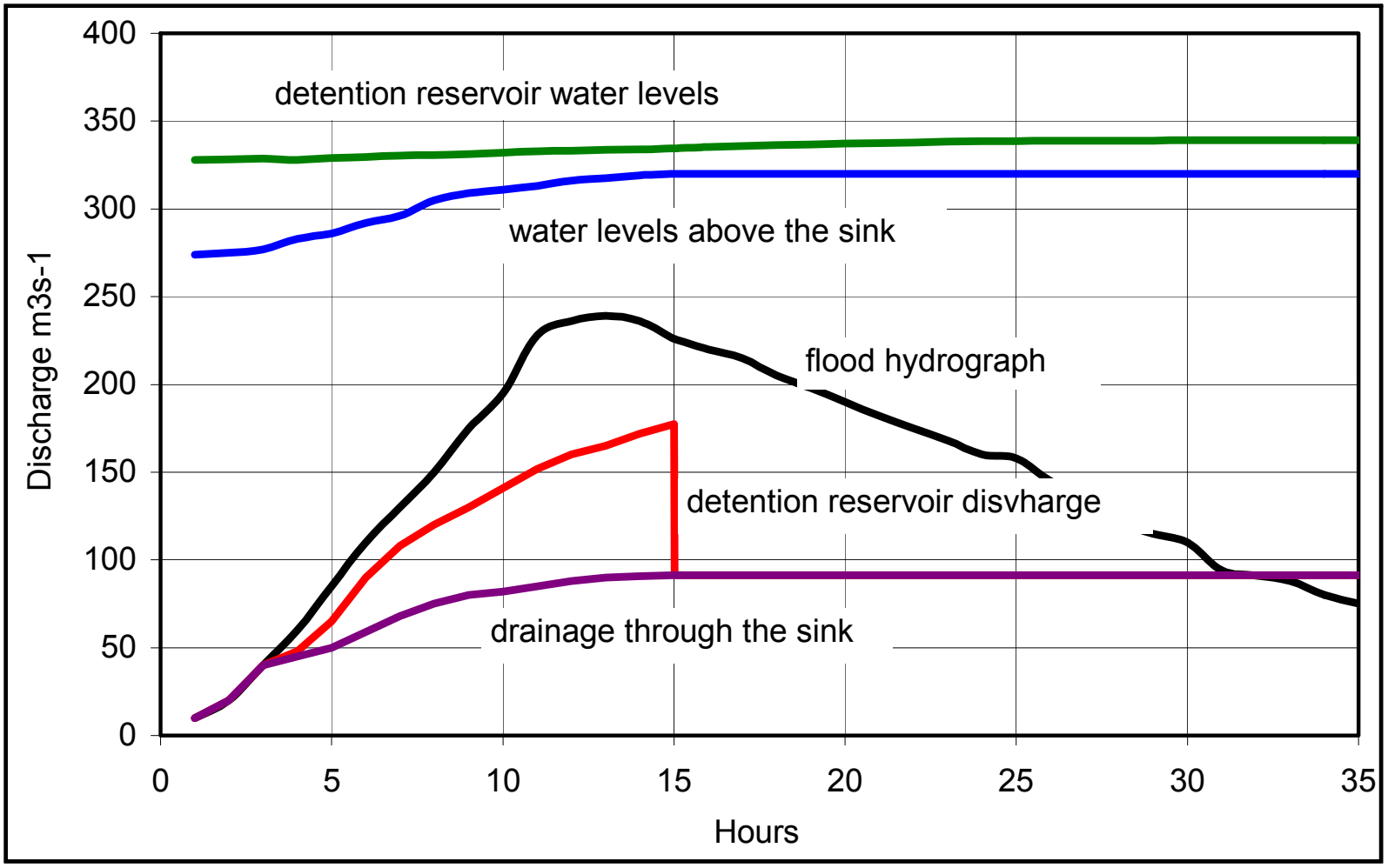
- Cleaning
- Regular maintenance
- Protection against floating objects

Hydropower plant operation security

Detention reservoir (in project)


Hreljin Ogulins

Detention reservoir operation rules



Conclusions

- Permanent sink maintenance and protection,
- Rainfall observation and forecast,
- Basin discharges measurement and forecast,
- Sink capacity control,
- Construct adequate structures (reservoirs; detention reservoirs; tunnels) and
- Develop areas outside flooded areas.